

WHAT IS CLAIMED IS:

1. An optical connector plug joined to a front end of an optical fiber cord covering an optical fiber and
5 removably inserted to one end of an optical adapter having a locking member for locking the optical connector plug in an engaged state, the optical connector plug comprising:
 - an inserted portion removably inserted to one end
10 of the optical adapter; - a plug body joined to a front end of the optical fiber cord; - a locking portion formed between the plug body and the inserted portion and locked by the locking
15 member of the optical adapter; and - a rotational phase reference surface formed on the plug body away from the locking portion.
2. An optical connector plug as claimed in claim 1,
20 further comprising:
 - a flange portion formed between the inserted portion and the plug body and having a larger diameter than those of the inserted portion and the plug body; - a tapered portion formed between the flange
25 portion and the plug body and having a conical inclined surface tapering from the flange portion toward the plug body; and

a notched portion formed in the tapered portion in association with the rotational phase reference surface and adjoining to the flange portion;

wherein the notched portion behaves as the locking portion.

3. An optical connector plug as claimed in claim 1 or 2, wherein the rotational phase reference surface is a pair of mutually parallel planes separated 180 degrees apart along a circumference of the plug body.

4. An optical connector plug as claimed in claim 1 or 2, wherein the optical fiber cord has a cross-sectional shape such that its dimension along a first direction perpendicular to a longitudinal direction of the cord and its dimension along a second direction perpendicular to the longitudinal direction and the first direction differ from each other;

wherein the plug body is joined to the front end of the optical fiber cord with the first and second directions associated with the rotational phase reference surface.

5. An optical connector plug as claimed in claim 1 or 2, wherein the optical fiber has a connecting end surface inclined with respect to an optical axis of the fiber and the rotational phase reference surface

is formed in association with a direction of inclination of the connecting end surface of the optical fiber.

- 5 6. An optical connector plug connecting method for optically connecting a given operated-side optical connector plug to a given stationary-side optical connector plug for optical connection by moving the operated-side optical connector plug between a connection block and an optical connector plug alignment block,

wherein the connection block has a plurality of optical adapters arranged in a predetermined alignment, to first ends of which are inserted the stationary-side optical connector plugs joined to front ends of stationary-side optical fiber cords,

wherein the optical connector plug alignment block has a plurality of guide passages formed therein in a predetermined alignment which can hold a plurality of operated-side optical connector plugs to be removably inserted in second ends of the optical adapters for optical connection with the stationary-side optical connector plugs and which allow a plurality of operated-side optical fiber cords joined at their front ends with the operated-side optical connector plugs to pass therethrough,

wherein the operated-side optical connector plugs

each have a rotational phase reference surface,

the optical connector plug connecting method comprising the steps of:

gripping with a handling device the rotational
5 phase reference surface of the given operated-side optical connector plug held in the optical connector plug alignment block;

moving the operated-side optical connector plug gripped by the handling device toward the connection
10 block;

putting the operated-side optical connector plug gripped by the handling device opposite the given stationary-side optical connector plug held in the connection block; and

15 inserting the operated-side optical connector plug gripped by the handling device into the second end of the optical adapter in a state such that the rotational phase reference surface of the operated-side optical connector plug is associated with the
20 stationary-side optical connector plug.

7. An optical connector plug connecting method as claimed in claim 6, wherein the step of moving the operated-side optical connector plug toward the con-
25 nection block is performed away from a cord stretching plane in which the plurality of operated-side optical fiber cords extend between the connection block and

the optical connector plug alignment block.

8. An optical fiber cross-connection apparatus comprising:

5 a connection block having a plurality of optical adapters arranged in a predetermined alignment, to first ends of which are inserted stationary-side optical connector plugs joined to front ends of stationary-side optical fiber cords and to second ends of
10 which are removably inserted operated-side optical connector plugs for optical connection with the stationary-side optical connector plug;

a plurality of locking members provided to the connection block to lock the operated-side optical
15 connector plugs to the optical adapters;

an optical connector plug alignment block having a plurality of guide passages formed therein in a predetermined alignment which allow a plurality of operated-side optical fiber cords to pass therethrough
20 so that the operated-side optical connector plugs are lain between the optical connector plug alignment block and the connection block; and

a handling device to act on the locking member to unlocking the operated-side optical connector plug
25 from the optical adapter, and to grip the operated-side optical connector plug held in the optical connector plug alignment block and insert it into the

given optical adapter;

wherein the optical connector plug has:

an inserted portion removably inserted into one end of the optical adapter;

5 a plug body joined to a front end of the optical fiber cord;

a locking portion formed between the plug body and the inserted portion and engaged by the locking member; and

10 a rotational phase reference surface formed in the plug body away from the inserted portion and gripped by the handling device.

9. An optical fiber cross-connection apparatus as
15 claimed in claim 8, wherein the optical fiber cord has a cross-sectional shape such that its dimension along a first direction perpendicular to a longitudinal direction of the cord and its dimension along a second direction perpendicular to the longitudinal direction
20 and the first direction differ from each other;

wherein the plug body is joined to a front end of the optical fiber cord with the first and second directions associated with the rotational phase reference surface;

25 wherein the guide passages in the optical connector plug alignment block have a cross-sectional shape corresponding to that of the optical fiber cord.

10. An optical fiber cross-connection apparatus comprising:

5 a connection block having a plurality of optical adapters arranged in a predetermined alignment, to first ends of which are inserted stationary-side optical connector plugs joined to front ends of stationary-side optical fiber cords and to second ends of which are removably inserted operated-side optical connector plugs for optical connection with the stationary-side optical connector plug;

a plurality of locking members provided to the connection block to lock the operated-side optical connector plugs to the optical adapters;

15 a redundant cord storage unit into which an operated-side optical fiber cord joined at its front end with the operated-side optical connector plug is retracted after the operated-side optical connector plug is optically disconnected from the stationary-side optical connector plug;

20 an optical connector plug alignment block provided between the redundant cord storage unit and the connection block and having a plurality of guide passages formed therein in a predetermined alignment
25 which allow the plurality of operated-side optical fiber cords to pass therethrough so that the operated-side optical connector plugs are laid between the

optical connector plug alignment block and the connection block;

an optical fiber cord retraction means provided between the optical connector plug alignment block and
5 the redundant cord storage unit to retract the operated-side optical fiber cord of the optically disconnected operated-side optical connector plug into the redundant cord storage unit; and

a handling device to act on the locking member to
10 unlock the operated-side optical connector plug from the optical adapter, and to grip the operated-side optical connector plug held in the optical connector plug alignment block by the optical fiber cord retraction means and insert it into the given optical
15 adapter;

wherein the optical fiber cord retraction means has:

a retraction roller driven to rotate and having an outer circumferential surface formed with a plurality of guide grooves axially spaced at predetermined
20 intervals, the guide grooves being adapted to hold individual operated-side optical fiber cords;

a slider movable parallel to a rotating axis of the retraction roller; and

25 a rotatable idle roller supported on the slider so that it can be moved toward and away from the retraction roller and adapted to hold between it and the

retraction roller the operated-side optical fiber cord being retracted into the redundant cord storage unit.

11. An optical fiber cord retracting method for
5 retracting an operated-side optical fiber cord joined at its front end with an operated-side optical connector plug into a redundant cord storage unit after the operated-side optical connector plug is optically disconnected from a stationary-side optical connector
10 plug, wherein an optical connector plug alignment block is provided between the stationary-side optical connector plug and the redundant cord storage unit, wherein the optical connector plug alignment block has a plurality of guide passages formed therein in a
15 predetermined alignment which allow a plurality of the operated-side optical fiber cords to pass therethrough, wherein the operated-side optical connector plugs are laid between the stationary-side optical connector
20 plugs and the optical connector plug alignment block, wherein the operated-side optical fiber cords have a cross-sectional shape such that its dimension along a first direction perpendicular to a longitudinal direction of the cord is larger than its dimension along a second direction perpendicular to the longitudinal
25 direction and the first direction and the operated-side optical fiber cords are held between the stationary-side optical connector plugs and the optical con-

necter plug alignment block so that the first direction of the cords is vertical, the optical fiber cord retracting method comprising the steps of:

twisting the operated-side optical fiber cords
5 between the optical connector plug alignment block and the redundant cord storage unit so that the first direction is horizontal; and

retracting the operated-side optical fiber cords into the redundant cord storage unit with the first
10 direction of the cords set horizontal.

12. An optical fiber cord retracting method for retracting an operated-side optical fiber cord into a redundant cord storage unit by using a retraction
15 roller and an idle roller after an operated-side optical connector plug joined to a front end of the operated-side optical fiber cord is optically disconnected from a stationary-side optical connector plug, wherein the retraction roller holds a plurality of the oper-
20 ated-side optical fiber cords in a predetermined alignment and the idle roller holds between it and the retraction roller the operated-side optical fiber cords, the optical fiber cord retracting method comprising the steps of:

25 moving the idle roller to a position facing the operated-side optical fiber cord to be retracted into the redundant cord storage unit;

pressing the idle roller against the operated-side optical fiber cord to be retracted into the redundant cord storage unit so that the operated-side optical fiber cord is held between the idle roller and the retraction roller; and

driving the retraction roller to retract the operated-side optical fiber cord held between the retraction roller and the idle roller into the redundant cord storage unit.

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13. An optical fiber cord retraction device provided between a redundant cord storage unit and the optical connector plug alignment block to retract an operated-side optical fiber cord joined at its front end with
15 an operated-side optical connector plug into the redundant cord storage unit after the operated-side optical connector plug is optically disconnected from a stationary-side optical connector plug, wherein the optical connector plug alignment block has a plurality
20 of guide passages formed therein in a predetermined alignment which allow a plurality of the operated-side optical fiber cords to pass therethrough, wherein the operated-side optical connector plugs are lain on that side of the optical connector plug alignment block
25 which is opposite the redundant cord storage unit, the optical fiber cord retraction device comprising:

a retraction roller driven to rotate and having

an outer circumferential surface formed with a plurality of guide grooves axially spaced at predetermined intervals, the guide grooves being adapted to hold individual operated-side optical fiber cords;

5 a slider movable parallel to a rotating axis of the retraction roller; and

 a rotatable idle roller supported on the slider so that it can be moved toward and away from the retraction roller and adapted to hold between it and the
10 retraction roller the operated-side optical fiber cord being retracted into the redundant cord storage unit.

14. An optical fiber cord retraction device as claimed in claim 13, further comprising a guide block
15 provided between the retraction roller and at least one of the optical connector plug alignment block and the redundant cord storage unit and having a plurality of guide passages formed therein in a predetermined alignment which allow a plurality of the operated-side
20 optical fiber cords to pass therethrough.

15. An optical fiber cord retraction device as claimed in claim 13 or 14, wherein the guide grooves of the retraction roller are smaller in width, as
25 measured along the rotating axis of the retraction roller, than the operated-side optical fiber cords.

16. An optical fiber cord retraction device as
claimed in claim 13 or 14, wherein the guide grooves
of the retraction roller are larger in width, as meas-
ured along the rotating axis of the retraction roller,
5 than the operated-side optical fiber cords and have a
depth smaller than the width of the operated-side
optical fiber cords as measured in a direction perpen-
dicular to the rotating axis of the retraction roller.
- 10 17. An optical fiber cord retraction device as
claimed in claim 13 or 14, wherein the guide grooves
of the retraction roller are larger in width, as meas-
ured along the rotating axis of the retraction roller,
than the operated-side optical fiber cords and have a
15 depth larger than the width of the operated-side opti-
cal fiber cords as measured in a direction perpendicu-
lar to the rotating axis of the retraction roller,
wherein at least an outer circumferential portion
of the idle roller is smaller in width than the guide
20 grooves.
18. An optical fiber cord retraction device as
claimed in claim 14, wherein the guide passages in the
guide block extend perpendicular to the rotating axis
25 of the retraction roller and tangential to the guide
grooves.

19. An optical connector plug alignment block provided between a connection block and a redundant cord storage unit, wherein the connection block has a plurality of stationary-side optical connector plugs
5 attached therein in a predetermined alignment which are to be optically connected with operated-side optical connector plugs, wherein the redundant cord storage unit accommodates operated-side optical fiber
10 cords joined at their front ends with the operated-side optical connector plugs after the operated-side optical connector plugs have been optically disconnected from the stationary-side optical connector plugs, wherein the operated-side optical connector
15 plugs are laid between the optical connector plug alignment block and the connection block, wherein the operated-side optical fiber cords have a cross-sectional shape such that its dimension along a first
direction perpendicular to a longitudinal direction of the cords is larger than its dimension along a second
20 direction perpendicular to the first direction and the longitudinal direction, the optical connector plug alignment block comprising:

a first alignment unit having a plurality of guide passages formed therein in a predetermined
25 alignment which allow the operated-side optical fiber cords to pass therethrough so that the first direction of the operated-side optical fiber cords is vertical;

and

a second alignment unit provided between the first alignment unit and the redundant cord storage unit and having a plurality of guide passages formed therein in a predetermined alignment which allow the operated-side optical fiber cords to pass therethrough so that the first direction of the operated-side optical fiber cords is horizontal.